Development of A Blended Learning Support For An Introductory Calculus Course at a Distance Learning Institution

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Abstract. Introductory Calculus is a basic and compulsory course for the new students of Faculty of Mathematics and Natural Sciences. Data of students' grades in the fall semester of 2013 showed that from 263 students who took the course exam, about 56 got grade E, which is categorized as fail, and 97 got grade D, which is categorized as borderline to fail. The big numbers of students who got E or D in the course was attributed to the less skill of the students in self-regulated learning especially in introductory calculus. Many of the students were fresh graduate of high school that do not have the skills to survive in the distance education system yet. The Mathematics department plan to develop a blended learning support program to develop student skills in learning the course and to survive the distance education system. The course already provides online tutorial which is not compulsory. It is planned to add the component of video conference to the online tutorial, to help the students feel as if they learn in a face-to-face classroom situation whereby they can meet with a teacher that can help them figuring out the solution to the difficulties they experience. The video conference is supposed to help the students to do in depth learning and develop skills necessary for the course. The video conference will be conducted four times to accompany the 8 times of online tutorials. The support program is within 8 weeks. This article will describe the planning and development of the blended learning support program based on the A (analysis) D (design) D (development) I (implementation) E (evaluation) model of instructional program development. It is hoped that the development can result in a model of student learning support for college mathematics in a distance learning systems.

Keywords: blended learning, video conference, online tutorial, introductory calculus

INTRODUCTION

Universitas Terbuka (UT) is the only higher education in Indonesia that exclusively conducting the teaching and learning activities utilizing the distance learning system. For the past 10 years UT enriched the teaching and learning activities, which is mainly through the print materials called Buku Materi Pokok (BMP), with the component of online tutorial for each course offered. The learning materials are furthered enriched by the provision of instructional video, web supplements, online exam exercises, and Internet TV. All of these materials can be accessed by the registered students. The

library also has a website call virtual reading room, where by students can access the BMP or other learning materials.

The catalogue of UT programs has guidance about how to study in a distance learning system. The students are expected to actively regulate them selves to study the BMP, access and interact in the online tutorial, do the exercises and formative test in the BMP, and access the materials available in the UT website. This catalogue is given to each registered student. Students can also access the catalogue from the UT website.

Apparently, many new students still experience difficulties in learning, especially Mathematics courses, in a distance system. UT already established provision of many kinds of tutorial, such as face-to-face tutorials that are compulsory for students registered in the School Education, and the online tutorials available for each course offered by UT. Other forms of tutorial are the broadcasted TV and radio programs, webinars, and through print media such as newsletter and UT magazine named Komunika. A survey conducted for Mathematics students' preference of tutorial modes revealed that they like face-to-face tutorial. However this kind of tutorial cannot be offered if the number of students are less than 20 and, only be offered, if any, at the 37 regional offices. The Mathematics students in each regional office are only five or less, if any. The problem of finding the Mathematics college teachers to give the various Mathematic courses also be a hindrance in offering the face-to-face tutorial, except if the students want to pay for the provision of the tutorials.

Introductory calculus has to be taken by all of new Faculty of Mathematics and Natural Sciences students who are not transferred from other higher institutions. Since the data showed that the performance of more than half of the students taken the course are just at the level of D or E, the Department of Mathematics created the intervention of combining the online tutorial of the Calculus course with the video conference in an approach that named as blended learning support.

LITERATURE REVIEW

The review will describe the ideas about Introductory Calculus delivered by utilizing distance learning approach.

Introductory Calculus

The following is the explanation about the term Calculus given by Flashman (2000)

> "..a "calculus" is a method for systematically determining a result, for arriving at a conclusion, or for calculating an answer [1]. In this sense there are many calculi, such as the calculus of propositional logic, the calculus of set operations, the calculus of probabilities, etc. But when someone talks about "The Calculus," be it "differential" calculus, "integral" calculus, or the calculus of infinite series, the reference is usually to "The Calculus of Isaac Newton (1642-1727) and Gottfried Leibniz (1646-1716)." This calculus provides **procedures for solving problems in the analysis of change**: determining rates of change, predicting the amount and explaining the quality of change, and connecting the concepts of change with the language and symbolism of algebra that describes change. This calculus also

develops tools for solving problems of geometry: determining a line tangent to a curve or finding the area of a planar region, predicting the shape and explaining the graphic qualities of a curve, and connecting these geometric concepts to the language of algebra that describes geometry.
Since its early development, calculus has grown more important. Its analysis has been applied in many contexts: the physical sciences and engineering, the life sciences, economics, probability. In fact calculus has uses in practically any area of study where change is important. It provides a theoretical basis as well as a practical tool for exact and estimated solutions to problems in almost every scientific discipline."

In the Indonesia situation the causes of low performance in introductory courses are lack of mathematics foundation in high school education to prepare students to survive the college mathematics, for major and non-major alike; wrong teaching methods and lack of qualified teachers that motivate students to study mathematics, and insufficient time students allotted to studying the course. So in this intervention the authors will integrate the diagnostic test, to analyze the entry behavior of students in term of prerequisite skills needed for the introductory course, to the blended learning support to help students overcome the difficulties in learning the important introductory calculus course.

Many studies show that there is a relation between performance in introductory college level Mathematics and Sciences and student retention and graduation from the STEM (Sciences, Technology, Engineering, and Mathematics) fields (Moore, and Shulock, 2009, p.4). Successful completion of a first –year math course (earning a C or better), is one of many factors that increased the probability of re-enrolling, and reduced the chances of student transfer or dropout (Herzog, 2003, 2005). Students who performed marginally in math and science during their first semester or first year of college were more likely to withdraw from the STEM curriculum than students who performed well (Gilmer, 2007).

It is worth the effort of a higher education institution to create an intervention strategy to prevent students' dropout or stop out that is appropriate to the students characteristics, especially at the freshman and sophomore level.

The Teaching of Introductory Calculus

Summary of the research findings about strategies employed by higher education institutions to prevent potentials loss of students because they dropped out from STEM majors or from the college entirely – especially through the improving their performance in foundational mathematic courses, are as followed (Hanover Research Report, 2011). Encouraging the student centered learning methods to promote active, cooperative, and inductive learning and prevent passivity. Since most STEM student already very familiar with the latest development in technology, integrating technology into the mathematic instruction can engage students with course materials, the teacher and other students. Another teaching method is peer-led team learning (PLTL) that involves the use of small group workshops associated with specific objectives and guided by a trained peer leader. Still another one is emphasizing the real-world

application of math concepts as well as making connections between foundational materials and more advance topics.

Strategies employed in the delivery of online tutorials are as followed. Development in learning management systems and online course delivery methods make it possible for teachers to choose the ways to control the release of course content, according to specific criteria. Study by Fisher et al (2014) showed that the conditional release of course materials is particularly beneficial for students with lower overall grades compared to those with higher overall grades, since they reported of being more engaged in the courses. Fisher et all (2014) describe that the criteria for the conditional release of course materials, i.e.: it should be reasonable and realistic, it is best used with activities or assignment that lead to the mastery of the course content, and it is best used when course content progresses linearly or builds on itself (p 230). The courses surveyed by the authors are upper level online agricultural economic course, online general education college algebra course, and a face-to-face elective mathematic course for at risk students.

In online courses, interactivity, especially between student-instructor, plays greatest role as an important component of satisfaction and persistence of the online learners (Croxton, 2014). Types of online interactivity vary according to the types of learner, which is undergraduate students regard the student-student interaction higher than the graduate or the professional ones (Croxton, 2014, p 317). Student-content interaction is also strongest student-level predictor of student satisfaction in online courses (Croxton, 2014, p. 315). Decreased social interactivity can lead to lowered satisfaction among students and increased feelings of isolation, disillusionment, and greater risk of dropping out of the online environment.

Kelton (n.d.) suggests strategies in teaching face-to-face mathematics course that can be modified to the online course. The strategies are: building rapport with students and encourage them to study within the pace allowed by the institution while still considering their individual differences. The teacher should be approachable and patience as a teacher, reward hard work, distinguishes mathematical achievement from intelligence, that is never belittling a student's difficulties in studying the course. In teaching an introductory mathematics course, the teacher should ensure that all students have the necessary prerequisite skills. It is advised that the teacher should progress slowly in the first sessions of the course and respond kindly to questions.

These advices can be implemented in the online course at the video conference sessions or be modified to be implemented at the online session.

Dibbs, Glassmeyer, and Yacoub (2013) suggest a strategy called precision teaching in delivering an introductory calculus course. Precision teaching is an instructional model that applies formative assessment to gain information on what topics are understood by the students as well as ones that they find difficult. With the information, the instructor can adjust the course to integrate supplementary materials or intervention strategies most beneficial to students. Their research suggests that formative assessment could (a) be used by instructors to make decisions to productively use class time, and (b) improve study skills for the students, which will lead to higher achievement and possibly better

understanding in calculus (Dibbs et al, 2013, p 3). The findings of the qualitative research showed that students who passed the course felt that precision teaching made a huge different in their ability to understand the materials at the pace the course run (Dibbs et al, 201, p 12)

There are many website suggest about how to improve student motivation and improve college student retention and learning. One of the web sites named Ed Tech Dev is a blog by Doug Holton. The blog describe two courses that made a difference in student retention, i.e.: learning and motivation strategies offered by Ohio State University and a compulsory calculus course for engineering students. Furthermore, he suggests additional strategies such as: making the course relevant and engaging to students, applying active learning, meaningful faculty-student interaction, reaching out and helping struggling students, coaching students, offering orientation program, teaching study skills, time management, and other student success strategies, discussing with students about their attitudes, motivation, and career goals, mentoring program by peer or faculty, developing learning communities, teaching for understanding not just for the test, keeping track of students, and supporting learners online,

The suggestions from the literature, about teaching introductory calculus, will be integrated into the blended learning program in various ways. The motivation and learning strategies, to survive the distance education system, are already available at and accessible from the UT website. The student-teacher/content/student interaction will be accommodated in the online tutorials and video conferences sessions, the diagnostic of prerequisite skills will be given in the online tutorials and discussed in the video session, and the difficulties students encountered in learning the calculus will be solve in the online tutorials and the video conference.

OBJECTIVES

The development of the blended learning support aims a) to provide an alternative to the types of tutorial that can be developed and implemented in UT, and b) to develop learning support to improve student performance in the introductory calculus as well as to prevent dropout.

METHODOLOGIES

The development of the blended learning support and the improvement of the existing online tutorial for the introductory calculus course will be following the ADDIE model for educational/training program development. ADDIE stands for Analysis, Design, Development, Implementation and Evaluation.

At the analysis stage the authors conducted the preliminary analysis of: student performance in the introductory calculus course at last year (2013), the relevant literature to gain insights about what should be integrated into the program, available relevant existing materials to be integrated to the program, the schedule and people that should be involved in the program.

At the development stage the author developed the competency map and a table of outline tutorial with the time.

This paper describes the analysis and development stages of the blended learning support program which will be implemented for 8 weeks in September to October 2014.

RESULTS AND DISCUSSION

Analysis Stage

The rationale for developing the blended learning support for the introductory calculus course are as followed.

In the first semester of 2013 the number of students enrolled and took the final exam were 236. This number are much more than the number of students registered for other mathematics courses which are usually 10 to 50 students per course. This course has to be taken by students in the Mathematics, Statistics, and Biology departments, hence the large enrollment in this course.

The students were dispersed at the 32 regional offices all over Indonesia. The number of students in each office were 1 to 59 students. The regional office with the most number of students is the one in Jakarta, the capital of Indonesia.

There is no face-to-face tutorial for any mathematics course since the number of students who wants this service are less than 20 per course as required by UT for the regional office to offer this service. The online tutorial is the only tutorial mode for students who take any mathematics course offered by the Department of Mathematics.

The introductory calculus course is supposed to be taken in the first semester a student registered at UT, so this course is a foundation course. As described by Croxton (2014), the interaction between student- instructor plays the most important role in student persistence in the online course. If students cannot overcome the difficulties in the first online courses they take, they are prone to not enrolled to similar course or to dropout from the Mathematics, Statistics or Biology program.

The blended learning support for the introductory calculus course is supposed to provide improved learning support to help students learn the course, and created an illusion of face-to-face help through the video conference component of the program. The video conference makes it possible to students to observe the teacher and other students discussing the course and hopefully learn from the interaction.

Design Stage

The authors developed the competency map as seen in Appendix. The outline of topics to be covered in each of the components of the blended learning support is described in Table 1.

Table 1: Outline of the Blended Learning Support of Introductory Online Calculus

Time of The Tutorial (Week)	Tutorial Topics	
	Online	***Video Conference***
0	*1 – 7 September 2014* **Introduction, describing:** - The mechanism of the blended tutorial program, online and video conference (vicon) - Learning and Motivation Strategies - Course Syllabus, Competency map and Concept Map as an advance organizer to give students the overall picture of the course	*10 September 2014* Detail Explanation and Q&A about: - The mechanism of the blended tutorial program, online and video conference (vicon) - Learning and Motivation Strategies - Course Syllabus, Competency map and Concept Map as an advance organizer to give students the overall picture of the course
I	*01 - 07 September 2014* **Interaction 1** - Set Theory - Real Number System - Group Assignment 1	
II	*08 – 14 September 2014* **Interaction 2** - Function - Limit Function - Group Assignment 2	
III	*15 -21 September 2014* **Interaction 3** - Continuity - Group Assignment 3 - Individual Assignment 1	*17 September 2014* Discussion/Q&A about topics covered in week 1 – 2
IV	*22 – 28 September 2014* **Interaction 4** - Derivative - Group Assignment 4	
V	*29 Sept – 05 October 2014* **Interaction 5** - Advance Derivative - Group Assignment 5 - Individual Assignment 2	
VI	*06 – 12 October 2014* **Interaction 6** - Graph Drawing - Maximum and Minimum - Group Assignment 6	*08 October 2014* Discussion/Q&A about the topic covered in week 3 – 5

Time of The Tutorial (Week)	Tutorial Topics	
	Online	***Video Conference***
VII	*13 – 19 October 2014* **Interaction 7** - Differenciable functions - Group Assignment 7	
VIII	20 – 26 October *2014* **Interaction 8** - Integral - Group Assignment 8 - Concluding the topics covered from week 1 - 8	*22 October 2014* Discussion/Q&A about topics covered in week 6 - 8

Development Stage

All the learning materials for the blended learning program already available in the website of Universitas Terbuka. The authors already repackaged the materials for the video conference and modified the materials on the online tutorials by linking it to the relevant materials in the institution website. The language in the learning materials is Bahasa Indonesia.

Implementation Stage

The implementation of the blended learning Support for the Introductory calculus will be conducted from September first until October 26 2014. The results of the implemented staged will be reported when the first author presents the paper in the AAOU conference.

Evaluation Stage

The evaluation of the program will be conducted from the analysis stage to the implementation stage, by observing the interaction in the online and vicon component of the program and revise the program as long as it can be done. The end program evaluation will be conducted by utilizing survey method to the students, tutors, developers, technicians, and administrators at the regional offices about what works and what doesn't work related to the program. The evaluation of result of the students learning will be conducted after grades are publishised, usually in the middle of December. Students grade from the first semester of 2014 can be compared to students grades from the first semester of 2013 to observe the impact of the program.

CONCLUSION

A blended learning support program is developed based on ADDIE model for an introductory calculus course offered by a distance learning institution. The blended learning support is supposed to help students to study the introductory online course and experience enjoyable learning process and result so that they can continue to register in

the next semester. The program integrated the various components that had been proven to help the students studying in a distance mode utilizing online tutorials and video conference, to help them develop the self-regulated learning ability while still provide them opportunity to get help through the online and vicon tutorials. This paper described the analysis to the development stages of the program. The implementation and the evaluation results will be reported at the time of the presentation of this paper by the first author.

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